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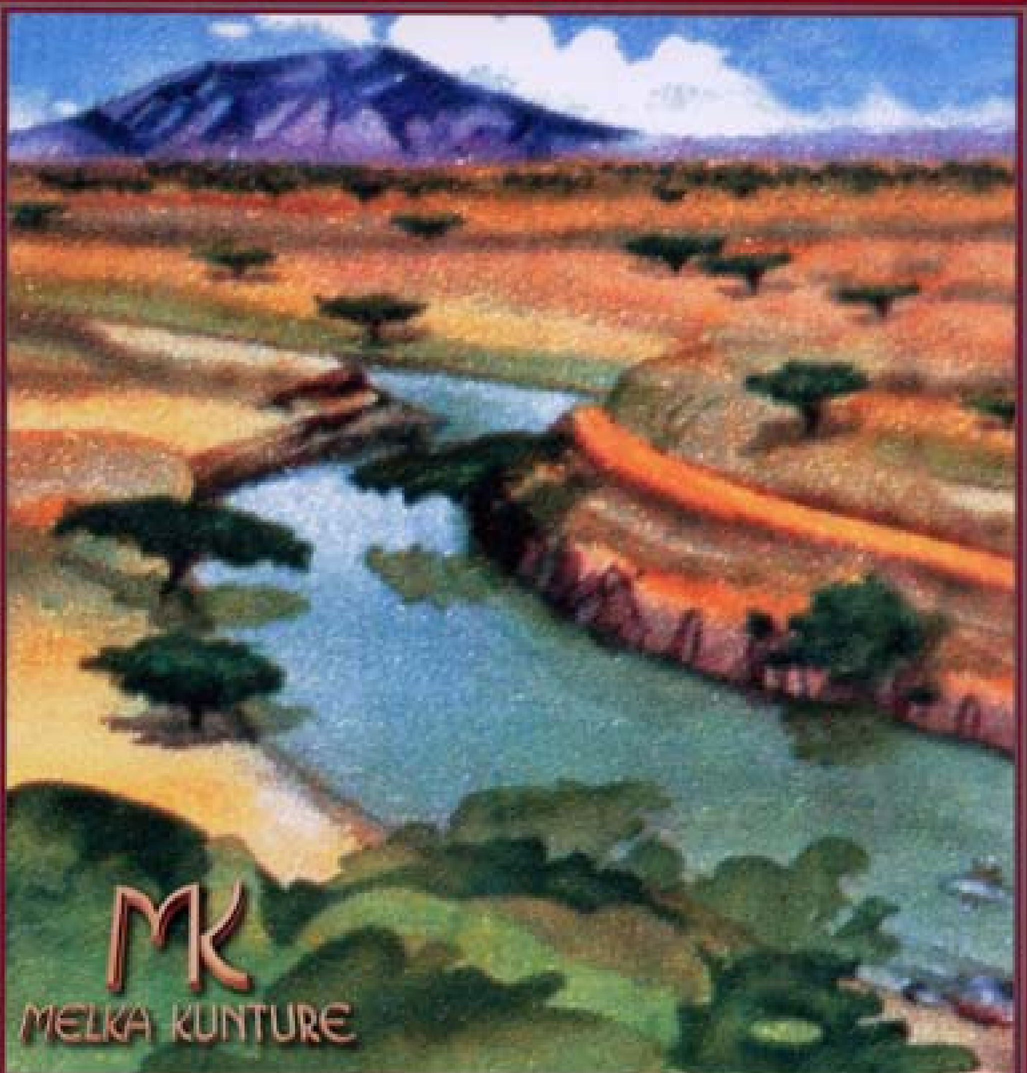

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Geology, volcanology and geochemistry

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Volcanic markers in coarse alluvium at Melka Kunture (Upper Awash, Ethiopia)

Guy Kieffer[1], Jean-Paul Raynal[2], Guillaume Bardin[3]

The knowledge we have today of the different volcanic episodes which occurred over the last several million years in the environment of the Melka Kunture prehistoric sites allows a new appraisal of the nature and abundance of emitted lavas that are represented in the alluviums of the Awash River and its tributaries. Moreover, the most compact facies can also be seen in the different archaeological sites. Several alluvial units and some archaeological layers have been sampled (Fig. 1) and petrographic counts performed on the basis of mainly macroscopic and some microscopic determinations of the lavas (Tab. 1). They allow comparisons between samples and offer a better understanding of local available raw materials for use by hominids.

Identified lavas and diagnostic minerals

The different rock types accepted for the petrographic counts are the following:

Basalt: melanocratic to mesocratic lava series, aphyric to feebly porphyric.

Micro-doleritic basalt: some are a little porphyric by the presence of feldspaths apparently alkaline.

Trachy-basalt: melanocratic to mesocratic lavas with phenocrystals of alkaline feldspaths.

Trachy-andesite: mesocratic lava, lighter than the basalts, with generally numerous large phenocrystals of alkaline feldspaths.

Aphyric fluidal differentiated rock: mesocratic to leucocratic lava, with a very clear fluidality and often vesicular, for example ancient lavas along the Melka Kunture fault. Benmoreite facies.

Sub-aphyric differentiated rock: mesocratic to leucocratic lavas, groundmass generally green-yellowish to white-yellow, with marked peripheric yellowish alteration (often considered as pseudo-cherts by archaeologists), more or less porous. Trachyte and rhyolite.

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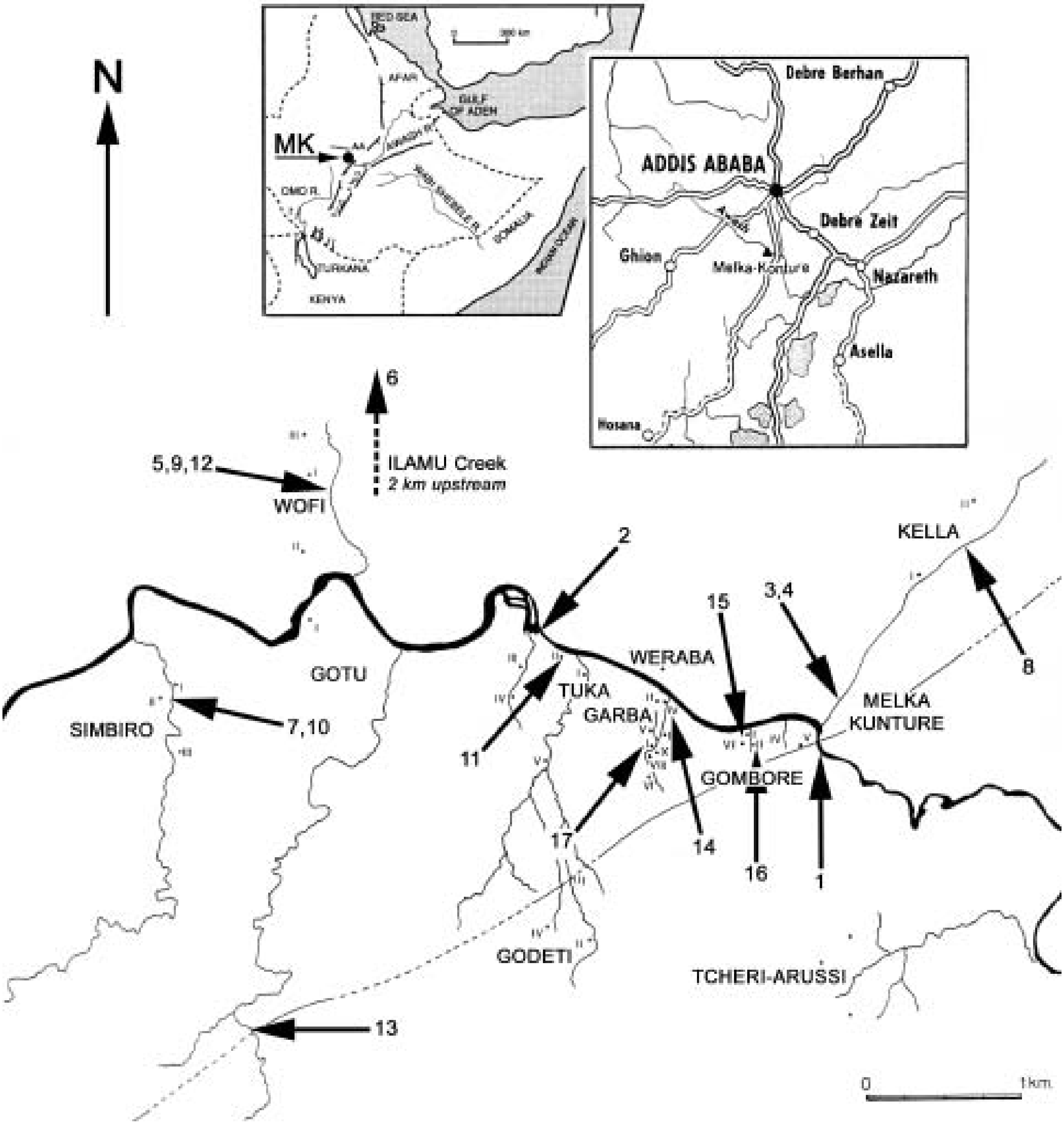

Fig. 1. Location map with sampling localities: Awash Gorge (1), Kella (3 present, 4 recent, 8 ancient), Gombore Iγ (15), Gombore II (16), Garba IV D (14), Garba I B (17), Melka Garba (2 present, 11 ancient), Simbiro (7 present, 10 ancient), Wutale lag-fall (13), Atebella (Wofi; 5 present, 9 ancient, 12 lag-fall), Ilamu Creek (6).

	Location:	Awash Gorge	Kella			Gombore I	Garba IV	Melka Garba		Atebella			Ilamu	Simbiro		Wutale
	Level:	present	present	recent	ancient	γ	D	present	ancient	present	ancient	lag-fall	recent	present	ancient	lag-fall
	Tachylitic basalt	0	2	1	0	1	2	0	6	0	0	0	5	3	6	0
P	Basalt	20	5	11	0	16	49	29	8	21	15	71	9	35	12	63
E	Doleritic basalt	6	17	15	0	0	0	0	0	0	0	0	1	0	0	0
T	Trachybasalt	12	8	8	0	5	6	10	0	1	9	8	18	18	2	11
R	Trachyandesite	3	0	0	0	3	2	15	20	1	1	1	0	10	8	0
O	Trachyte	15	1	1	0	12	20	3	5	25	13	13	3	5	0	0
G	Leucocratic differentiated aphyric rocks	25	6	2	23	14	38	18	34	26	27	12	52	20	16	17
R	Leucocratic differentiated porphyric rocks	23	48	57	54	15	14	11	26	8	7	36	20	14	35	46
A	Porphyric/aphyric differentiated rock: Phonolite	0	13	7	0	3	1	4	4	1	0	1	0	2	1	0
P	Obsidians	14	20	23	81	2	0	5	12	30	86	0	255	1	10	0
H	Syenitic xenolith	1	0	0	0	2	1	2	0	0	1	10	1	3	0	1
Y	Ignimbrites	40	38	19	0	70	40	29	13	64	8	0	22	57	29	1
	Tuffs	0	0	0	0	1	0	0	0	0	0	0	0	0	4	0
	Miscellaneous	2	2	1	14	0	1	0	1	0	2	8	4	0	4	0
	Total individuals:	*161*	*160*	*145*	*172*	*144*	*174*	*126*	*129*	*177*	*169*	*160*	*390*	*168*	*127*	*139*

	Location:	Awash Gorge	Kella			Gombore I	Garba IV	Melka Garba		Atebella			Ilamu	Simbiro		Wutale
	Level:	present	present	recent	ancient	γ	D	present	ancient	present	ancient	lag-fall	recent	present	ancient	lag-fall
	Tachylitic basalt	0,0	1,3	0,7	0,0	0,7	1,1	0,0	4,7	0,0	0,0	0,0	1,3	1,8	4,7	0,0
P	Basalt	12,4	3,1	7,6	0,0	11,1	28,2	23,0	6,2	11,9	8,9	44,4	2,3	20,8	9,4	45,3
E	Doleritic basalt	3,7	10,6	10,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0
T	Trachybasalt	7,5	5,0	5,5	0,0	3,5	3,4	7,9	0,0	0,6	5,3	5,0	4,6	10,7	1,6	7,9
R	Trachyandesite	1,9	0,0	0,0	0,0	2,1	1,1	11,9	15,5	0,6	0,6	0,6	0,0	6,0	6,3	0,0
O	Trachyte	9,3	0,6	0,7	0,0	8,3	11,5	2,4	3,9	14,1	7,7	8,1	0,8	3,0	0,0	0,0
G	Leucocratic differentiated aphyric rocks	15,5	3,8	1,4	13,4	9,7	21,8	14,3	26,4	14,7	16,0	7,5	13,3	11,9	12,6	12,2
R	Leucocratic differentiated porphyric rocks	14,3	30,0	39,3	31,4	10,4	8,0	8,7	20,2	4,5	4,1	22,5	5,1	8,3	27,6	33,1
A	Porphyric/aphyric differentiated rock: Phonolite	0,0	8,1	4,8	0,0	2,1	0,6	3,2	3,1	0,6	0,0	0,6	0,0	1,2	0,8	0,0
P	Obsidians	8,7	12,5	15,9	47,1	1,4	0,0	4,0	9,3	16,9	50,9	0,0	65,4	0,6	7,9	0,0
H	Syenitic xenolith	0,6	0,0	0,0	0,0	1,4	0,6	1,6	0,0	0,0	0,6	6,3	0,3	1,8	0,0	0,7
Y	Ignimbrites	24,8	23,8	13,1	0,0	48,6	23,0	23,0	10,1	36,2	4,7	0,0	5,6	33,9	22,8	0,7
	Tuffs	0,0	0,0	0,0	0,0	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,1	0,0
	Miscellaneous	1,2	1,3	0,7	8,1	0,0	0,6	0,0	0,8	0,0	1,2	5,0	1,0	0,0	3,1	0,0
	Total %:	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*

Tab. 1. Petrographic counts in different alluviums and some volcanic deposits in the Melka Kunture area.

Porphyric differentiated rock: pale coloured mesocratic to leucocratic lavas, with phenocrystals of alkaline feldspars and sometimes of quartz. Trachyte and rhyolite.

Porphyric fluidal rock: mesocratic lavas with groundmass of a phonolitic aspect (stepped greasy fracture).

In addition, there are rocks and minerals with a particular significance:

Inclusions with syenitic or microsyenitic aspect: which complete the range of trachytic to phonolitic facies.

Tachylites(?): which complete the range of melanocratic facies.

Bi-pyramidal quartz: present in the alluvium matrix of the Kella and Simbiro gullies, in company with porphyric rocks of rhyolitic type and the ignimbrites.

Obsidian: three macroscopic types have been defined, the main one being the black banded lava of Balchit, and others relating to ignimbrites with obsidienic soles.

Welded ignimbrites: thirteen types of welded ignimbrites have been identified in the ancient alluviums of Simbiro. Among them, welded ignimbrite of type 1 is best represented.

We note in this sampling a magmatic bimodality, with melanocratic basalts on one hand and trachytes/rhyolites on the other. The intermediary facies seem less well represented. This is coherent with the regional magmatic phases (Woldegabriel *et al.* 1992; Chernet *et al.* 1998).

Remarks on some petrographic suites

Present alluviums of the Awash

The present alluviums of the Awash River (Fig. 1, *1*, *2*) are characterised by a high proportion of welded ignimbrite of type 1 and by melanocratic rocks of basaltic aspect (based upon macroscopic examination). Then come the differentiated rocks (including their fluidal facies) belonging to the “initial local volcanism” (Kieffer *et al.* 2002) and visible for example along the Melka fault or upstream in the Atebella tributary. Finally come the obsidians, apparently massively of Balchit type (Fig. 2). As we shall see hereafter, they represent an average balance of the different tributaries of left and right bank in the Upper Awash basin, as noted previously by Taieb (1974).

Present and recent alluviums of the tributaries

The present and recent alluviums of the Kella dale (Fig. 1, *3*, *4*) are clearly differentiated by the absence of fluidal rocks from the Melka fault and of basalts, the presence of microdoleritic basalt, of phonolite type rocks and the abundance of differentiated porphyric rocks (Fig. 3). Atebella present alluviums (Fig. 1, *5*) are dominated by welded ignimbrites and rocks from the “initial local volcanism” which form the bottom of the minor bed of the creek. Upstream of Atebella, Ilamu Creek is a left bank tributary (Fig. 1, *6*) which comes directly from the Balchit area: its recent alluviums are consequently very rich in obsidian. Simbiro recent alluviums (Fig. 1, *7*) on the contrary, are characterised by the abundance of basalts and ignimbrites and the near absence of obsidian.

Ancient alluviums of the tributaries

The left bank ancient alluviums at Kella and Atebella (Fig. 1, *8*, *9*). are characterised by the abundance of obsidian, but differ in their proportions of other components (Fig. 4). Those of Simbiro (Fig. 1, *10*) are dis-

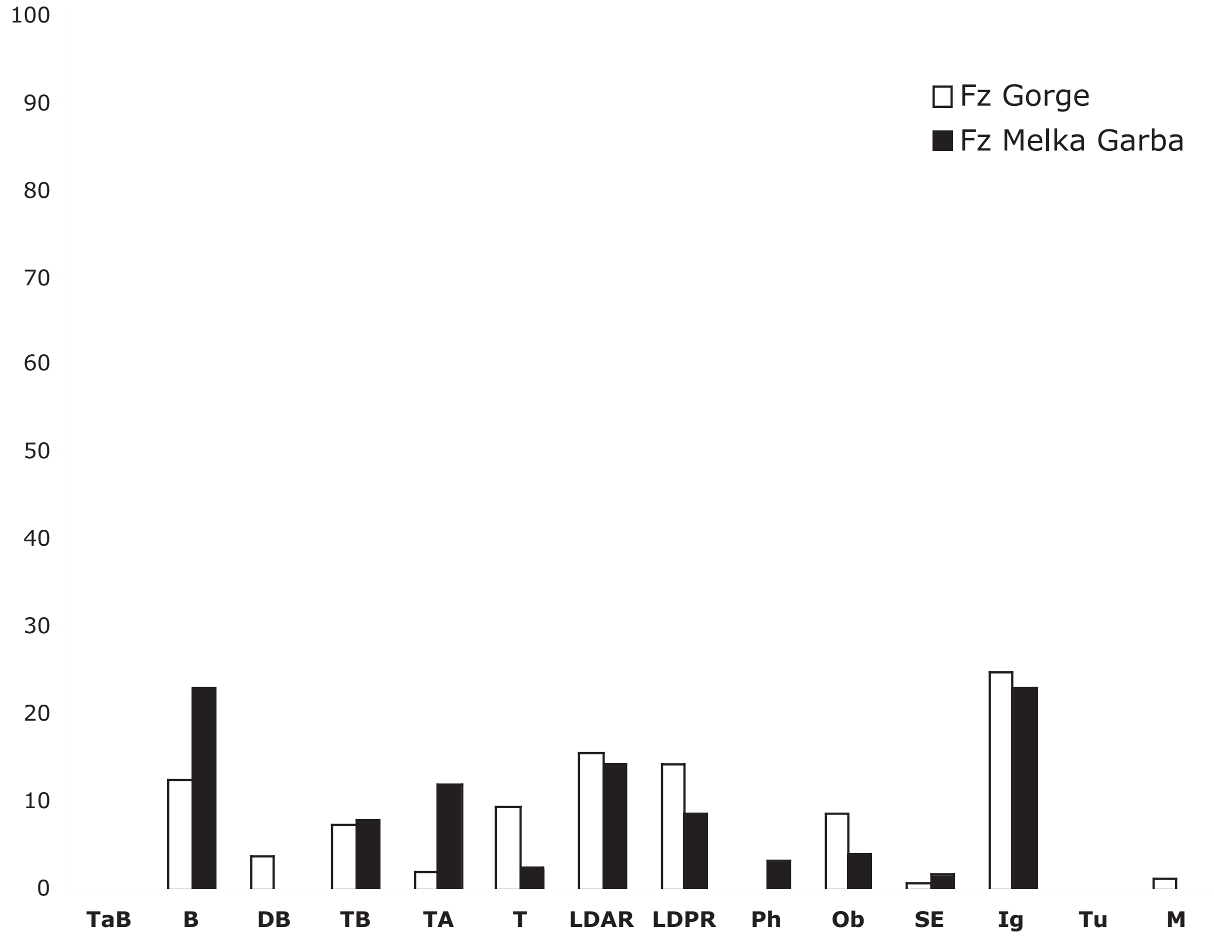

Fig. 2. Petrographic spectra of present alluviums of the Awash River.

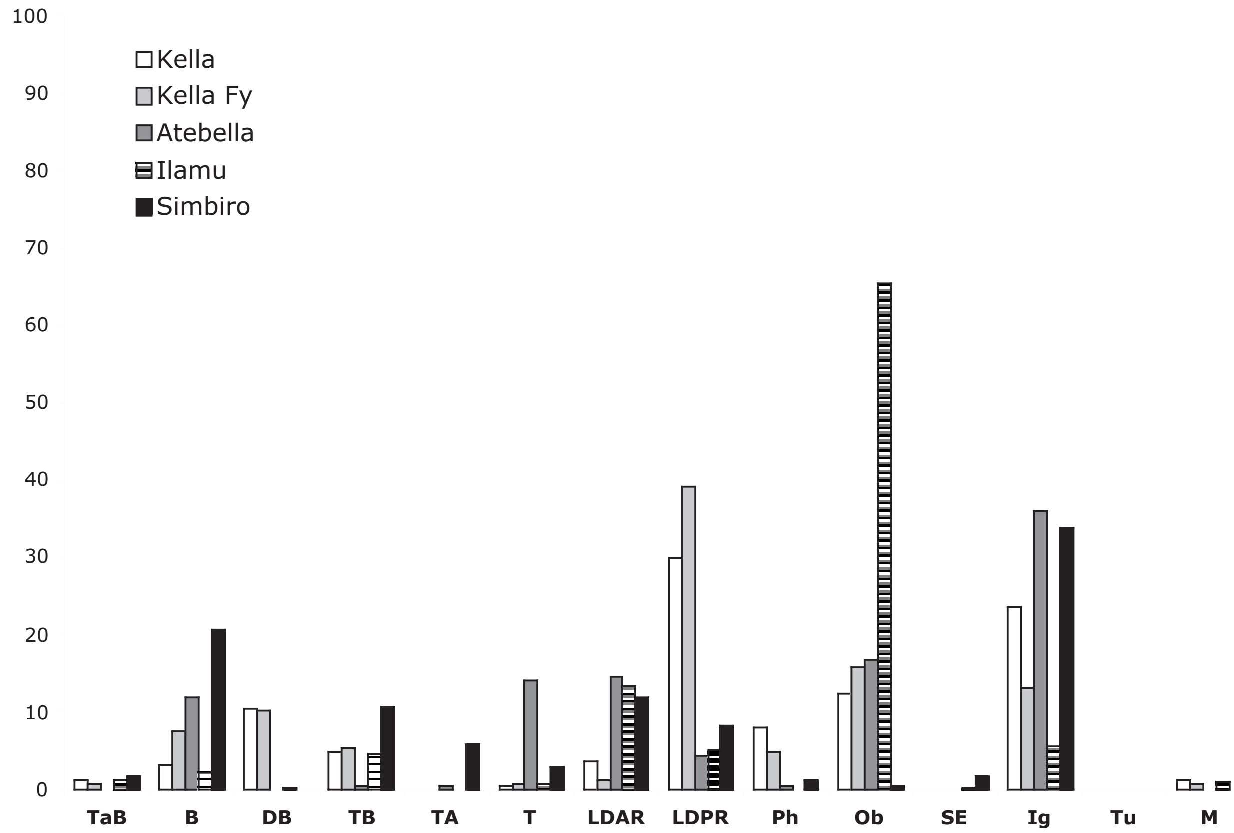

Fig. 3. Petrographic spectra of recent alluviums of the Awash tributaries.

tinguished by the variety of ignimbrites. The ancient alluviums of the Awash River at Melka Garba (Fig. 1, *11*) are characterised by the dominance of differentiated rocks and of fluidal rocks of the "initial local volcanism". The low proportion of ignimbrites can perhaps be explained by their lower resistance during their transportation within a major river course.

Coarse volcanic layers

Some peculiar volcanic deposits related to the "intermediary activity" are sometimes interbedded in alluvial deposits.

Atebella basal unit

The basal unit of the Atebella sequence (Fig. 1, *12*) was identified previously as a coarse conglomerate (Taieb 1974). When we re-examined this section, we considered it as a phreatomagmatic breccia because of the presence of numerous tempered elements (Kieffer *et al.* 2002). Besides the heterometric and angular aspect of its elements, it clearly differs from all the other alluvium's spectra by the abundance of basalt and total absence of welded ignimbrite type 1 and of obsidian (Fig. 5) and is more likely a lag-fall which shows a great similarity with that of Wutale.

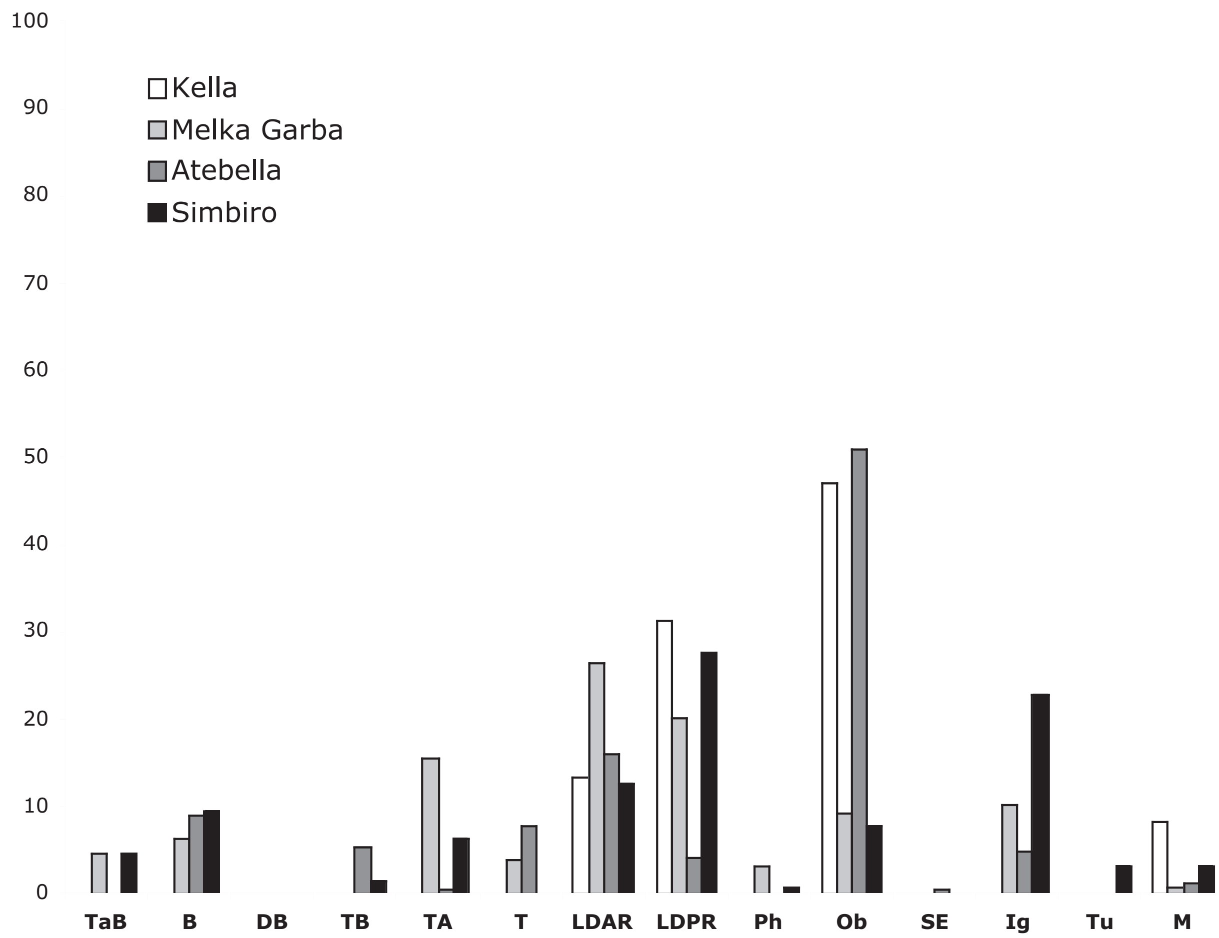

Fig. 4. Petrographic spectra of ancient alluviums of the Awash tributaries.

Wutale lag-fall

Upstream in Wutale Creek, a huge section is exposed along one of the main local faults (Fig. 1, *13*). A very coarse conglomerate from one to three metres thick composed of loose lavic elements that can reach ten centimetres in diameter (Fig. 5) is identified as a lag-fall unit which forms the base of an ignimbritic complex. A similar lag-fall unit was previously identified as a breccia upstream in the Simbiro Creek (Taieb 1974).

Archaeological units at the top of channel lag deposits

Garba IV Oldowan

The suite was studied using the material collected during the excavation of the Garba IV D archaeological unit (Fig. 1, *14*; Chavaillon and Piperno 1975). The various differentiated rocks and trachytes of the "initial local volcanism" dominate the suite (Fig. 6), followed by the basalts and the ignimbrites (mainly welded type 1) probably indicating a period of general erosion. The absence of obsidian may be the result of an anthropic action.

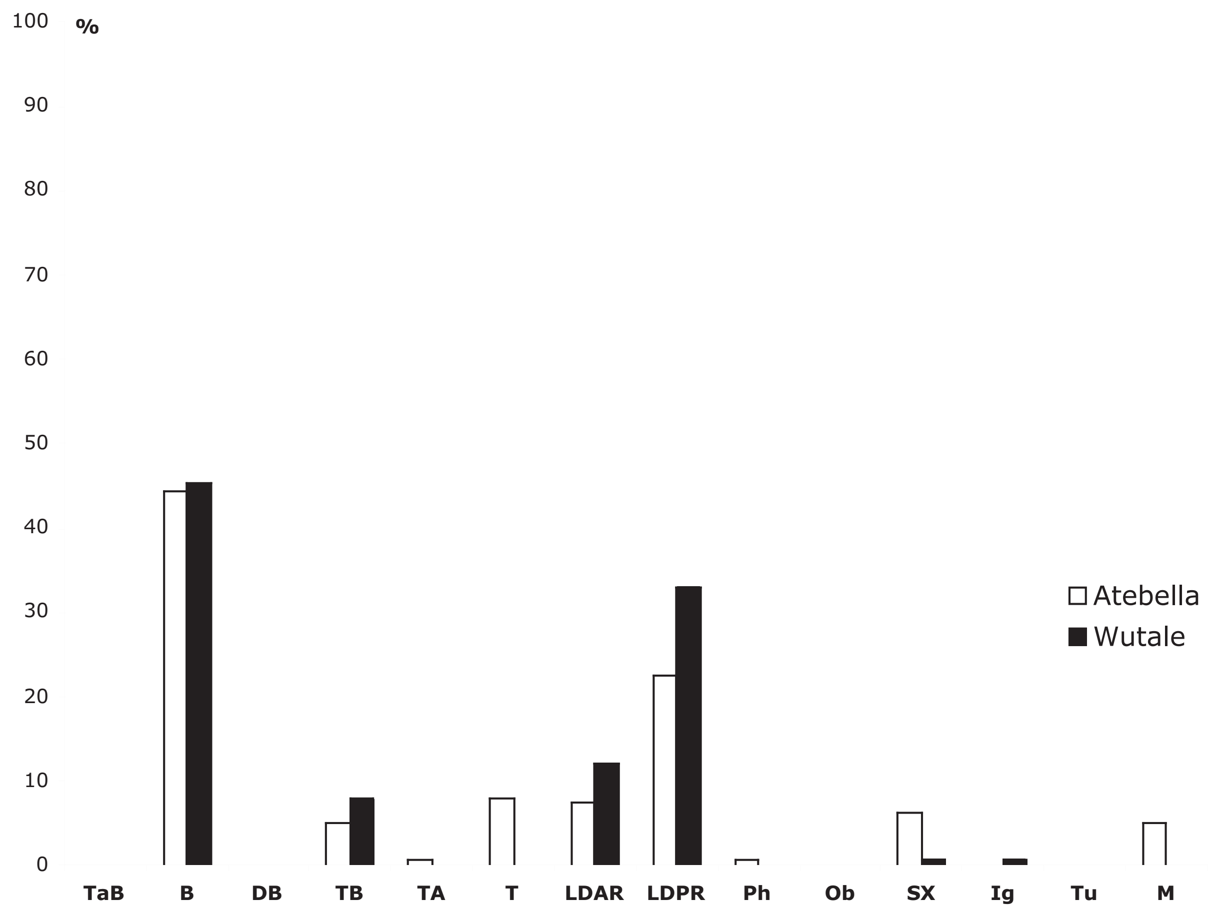

Fig. 5. Petrographic spectra of lag-falls.

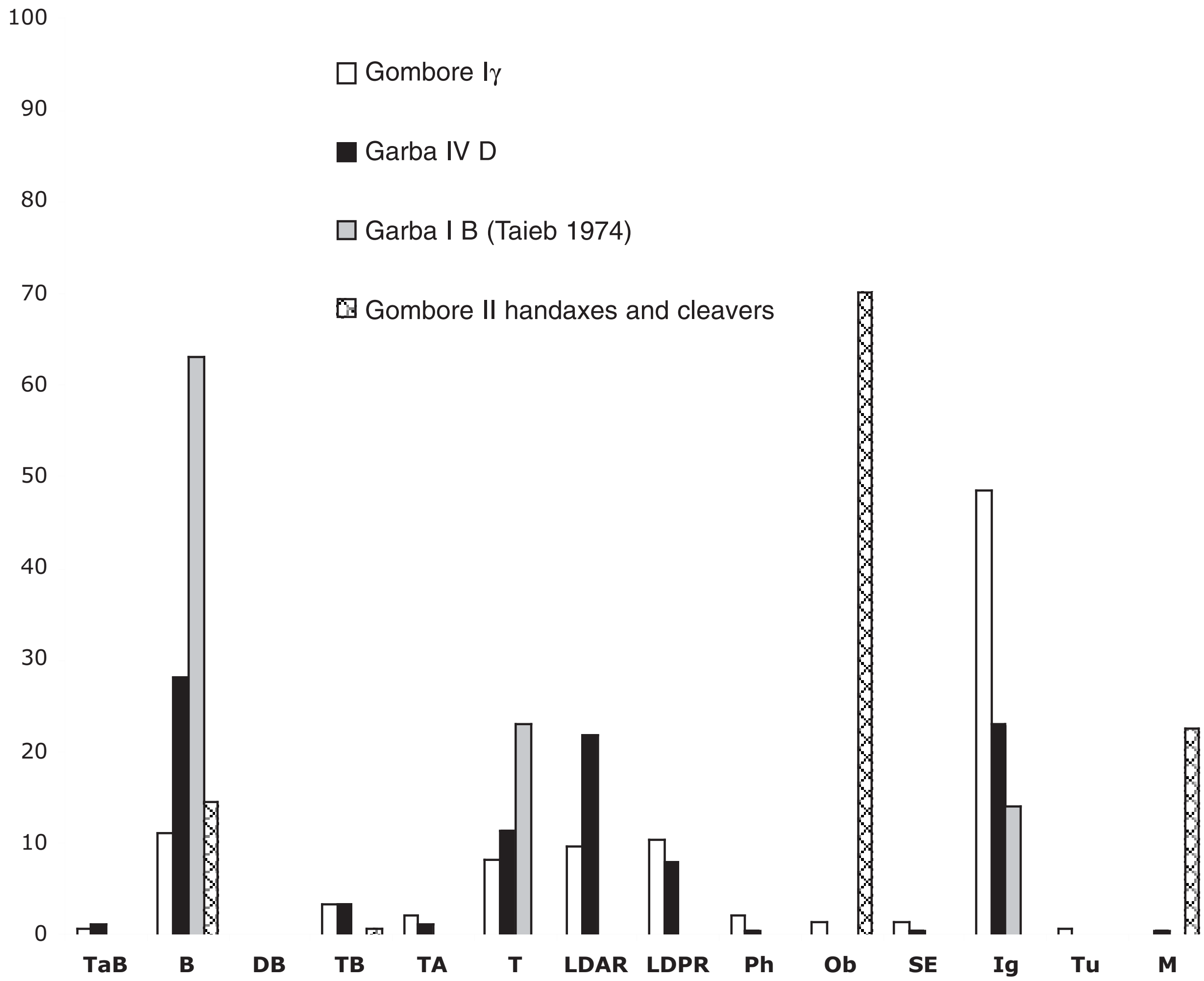

Fig. 6. Petrographic spectra of different archaeological layers.

Gombore Iγ Developed Oldowan/Lower Acheulian

The suite was studied using the material collected during the excavation of the Gombore Iγ (Fig. 1, *15*) by J.-L. Boiseaubert (Chavaillon *et al.* 1978). One notices the abundance of welded ignimbrites of type 1 followed by other rocks of the "initial local volcanism", which could indicate a period of global dismantling of ancient volcanic relief and important lateral contributions to alluvial processes (Fig. 5).

Gombore II Middle Acheulian

The archaeological site of Gombore II (Fig. 1, *16*; Chavaillon 1972) has been re-investigated and a large excavation was open in 2002. Handaxes and cleavers from this "occupation floor" are manufactured in obsidian, in varied basalts and in rocks believed to be mainly basalts and probably vitreous ignimbrites, but which bear patina and cannot be sectioned for accurate petrographic determination (Fig. 6).

Garba I-B Upper Acheulian

The pebbles from the archaeological unit of Garba I-B (Fig. 1, *17*; Chavaillon 1972) were identified by M. Taieb (1974). The suite consists of basalt (63%), trachyte (21%), trachytic tuff (10%), ignimbrite (4%)

and rhyolites (2%; Fig. 6). This composition reflects the composition of the "initial local volcanism" and of the "intermediary activity" and indicates probably a period of erosion of the faulted sector of Godeti.

Conclusions

As a result of this study of petrographic suites, it appears that the ancient and recent alluviums constitute a reliable registration of dynamic and sedimentary phenomena that affected the Melka Kunture basin, since the beginning of hominid occupation of the region.

Actually, the alluviums of the right bank tributaries demonstrate an evolution in time related to the different geodynamic phases of the Melka Kunture fault and the associated volcanism. Those of the left bank register the different stages that occurred during the dismantling of superficial formations covering the part of the valley between Melka Kunture and the Wachacha.

Finally, thanks to the study of the petrographic characteristics of some archaeological units, we identified some elements demonstrating the selection of specific raw materials by hominids (fine grained basalts, obsidian, aphyric and sub-aphyric differentiated lavas, etc.).

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